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Review

A Systematic Review on Utilizing the Acute to Chronic Workload Ratio for Injury Prevention among Professional Soccer Players

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Abstract: In recent years, there has been a surge in research examining the correlation between training load and injury risk among professional football players. One prominent model proposed for this purpose is the acute-to-chronic workload ratio (ACWR). This review aimed to compile studies focusing on professional footballers that explored the association between the ACWR and injury risk, offering specific usage guidelines. The findings revealed that the relationship between the ACWR and injury risk in professional football remains inconclusive. Among studies supporting this relationship, many utilized a coupled ACWR derived from GPS data. Interestingly, the duration of the ACWR (1:2, 1:3, 1:4) did not seem to significantly impact this association. In conclusion, the pool of relevant studies is limited, warranting further research for more definitive conclusions. While the ratio shows promise in its connection with injury risk, establishing precise thresholds (e.g., reduced injury likelihood) remains challenging given the current research landscape.

Keywords: acute/chronic workload ratio; soccer; professional; football; workload

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1. Introduction

Football is an exceptionally popular sport, engaging over 250 million athletes worldwide, with more than 130,000 being professional football players [1]. Since its inception, the sport has been continually evolving, with significant changes observed in recent decades. Both in older and contemporary studies [2,3] that investigated the evolution of football regarding its physical demands, it is mentioned that the number of sprints, the distance covered at maximum, and high-speed movements have increased. These findings indicate an escalation in intense actions during football matches.

Another aspect distinguishing contemporary football from previous decades is the increased number of games involving high-level teams. Players often participate in over 60 matches (league, national cup, European cups, national team), and this number is expected to rise [4]. Consequently, players frequently engage in three matches within an eight-day period. The elevated match frequency, combined with limited recovery time, may predispose players to muscle injuries [5].

Previous studies have suggested that high-level football players may experience two injuries during a sports season. Therefore, for a team with 25 football players, approximately 50 injuries are calculated, of which 28% are overuse injuries [6]. A recent review [7] reported that muscle injuries in European professional football result in a loss of 34.7 days for every 1000 h of participation, with a cost of EUR 203,620. The total cost of injuries in the top five European football leagues for the 2021/2022 season exceeded EUR 600 million [8]. In addition to the economic cost, teams must cope with the limited availability of injured players. A previous study indicated a positive relationship between player availability and team success and ranking [9].

As mentioned earlier, the combination of numerous matches and restricted recovery time may increase the likelihood of injuries [10]. To mitigate these injuries, the management of players' training load has been proposed [11]. Various methods have been developed to measure/estimate the external or internal load (heart rate monitoring (HR), rating of perceived exertion (RPE), and running distances covered at different speeds: total distance (TD), low-speed distance (LSD), high-speed distance, (HSD), sprint distance (SD), accelerations (ACC), and decelerations (DEC)) [12–14]. Load is categorized into internal and external loads. External load can be defined as the sum of actions completed by the player during a match and/or training (e.g., running 3000 m). Internal load can be defined as the physiological response of the body to the external load (e.g., heart rate). A model for monitoring the load was proposed by researchers over the past decade, showing a correlation with the occurrence of non-contact muscle injuries [11,15]. According to this model, the ratio of recent load (last week) to chronic load (last four weeks) is calculated. For example, if the total distance in the last week was 20,000 m, while in the previous three weeks, it was 18,000 m, 21,000 m, and 19,000 m, respectively, then the ratio is calculated as follows: ACWR = 20,000/average (20,000 + 18,000 + 21,000 + 19,000) = 1.03. Researchers suggest that when this ratio exceeds 1.5, the risk of player injury increases [16]. However, over time, sports scientists have tested modified models, considering the last two or three weeks in chronic load (referred to as ACWR 1:2 or 1:3) [12] or excluding the week of acute load from the chronic load [17]. The ACWR has been utilized in team sports such as football [12], rugby [15], and Australian football [17].

In the literature, studies both supporting and refuting the relationship between the ACWR and non-contact injuries exist [11,12,18–21]. More specifically, there are studies in team sports reporting that they observed a relationship between an increase in the ACWR value and the likelihood of injuries [11,12]. However, there are also studies whose findings do not support this relationship [21]. As mentioned earlier, this ratio has been used in different sports and different forms, factors that can influence the results. This review aims to gather studies exclusively related to professional soccer, present their findings, and determine whether the use of this ratio in soccer serves to predict the likelihood of non-contact injuries. Furthermore, in the case of studies that identified a correlation, the parameters demonstrating this relationship will be highlighted, along with the duration of the ratio used. The summary of research results will serve as a valuable tool for professionals in the field.

2. Methods

2.1. Eligibility Criteria

The studies selected for this review had to meet the following criteria: (1) being original papers in the English language, (2) investigating the relationship of the ACWR model with non-contact muscle injuries, (3) involving professional soccer players as the study sample, (4) describing the variables to which the ACWR was applied, and (5) documenting the injuries of soccer players. The examination of the above criteria in the selected studies was conducted by two reviewers.

2.2. Literature Search Strategy

The review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement guidelines [22]. The search for studies was carried out on several databases, including Scopus, SPORTDiscus, Google Scholar, Web of Science, and PubMed. The keywords used in the search included: "acute to chronic workload ratio" OR "ACWR" AND "workload" OR "training volume" OR "RPE" OR "sRPE" OR "global positioning system" OR "GPS" OR "total distance" OR "high speed running" OR "accelerations" OR "decelerations" AND "soccer" OR "football" AND "professional players" AND "injury" OR "non-contact" OR "muscle" NOT "animals" OR "illness" OR "disease" OR "amateur" OR "youth" OR "skeletal injury" OR "contact injury". The use of the above keywords for retrieving the desired research from the databases was performed by two reviewers. The literature search was conducted in February 2024.

2.3. Study Selection

After the above keywords were used and the studies were gathered, they were subsequently checked for their suitability. This verification was carried out by two reviewers. Specifically, initially, the reviewers examined the title and abstract of each study independently from each other. Disagreements regarding the suitability of a study were addressed through discussion between the reviewers.

2.4. Data Extraction and Management

After the selection of studies to be included in the review, their characteristics were extracted, and tables were created, as presented below. The tables included information such as authors, publication year, study duration, participants, the ACWR used, and the internal and external load indicators used for the ACWR. The association and the ability to predict injuries using the ACWR were derived from the results of each study individually. In the review, the findings were categorized based on the load indicators used, specifically distinguishing between the internal and external loads. The selection of the data used for this review was carried out by two reviewers.

2.5. Quality Assessment of the Studies/Risk of Bias

The quality of each study was assessed using the Newcastle–Ottawa Quality Assessment Scale (NOS) for cohort studies [23]. This scale, recognized by the Cochrane Collaboration [24], evaluates participant selection (4 criteria), comparability (1 criterion), and study outcomes (3 criteria). Each study was independently evaluated by two reviewers according to the above scale. In studies where a different quality rating was observed, disagreements were resolved through discussion between the two reviewers.

3. Results

3.1. Selection of the Studies

As mentioned earlier, the above-mentioned keywords were used for the study search. Initially, 247 articles emerged from the searches across all bibliographic databases. Subsequently, the removal of duplicate entries and articles that did not meet the selection criteria resulted in a final count of 12 articles deemed suitable for inclusion in the review. A flowchart illustrating the study selection process is presented in Figure 1. It is worth noting that all the studies included in the review are recent, although no limitations relating to the year of publication of the articles were applied to our research.

3.2. Methodological Quality of the Studies

All studies utilized in the work displayed an NOS score of ≥4. Depending on the rating each study received on the assessment factors encompassed by the NOS scale (selection, comparability, outcome), they could be classified as 'good', 'fair', or 'poor', following the guidelines of the US Agency for Healthcare Research and Quality [22]. Accordingly, seven studies were classified as 'good', one as 'fair', and three as 'poor' (Table 1).

Table 1. Quality assessment of the studies with the use of the Newcastle–Ottawa Scale.

Study	NOS Score			
	Selection	Comparability	Outcome	Total Score
Bowen et al., 2020 [25]	3	2	2	7, G
Carbone et al., 2022 [26]	3	1	2	6, G
Delecroix et al., 2018 [21]	2	1	2	5, F
Fanchini et al., 2018 [27]	2	1	1	4, P
Fousekis et al., 2023 [12]	3	1	2	6, G
Jasper et al., 2018 [19]	4	1	0	5, P
Malone et al., 2017 [28]	3	1	2	6, G
Mohr et al., 2023 [29]	3	1	2	6, G
Nobari et al., 2022 [30]	2	1	1	4, P

Table 1. *Cont.*

Study	NOS Score			
	Selection	Comparability	Outcome	Total Score
Ribeiro-Alvarez et al., 2023 [31]	3	1	2	6, G
Suarez-Arrones et al., 2020 [32]	3	1	1	5, P
Tiernan et al., 2022 [33]	3	1	2	6, G

G, good; F, fair; P, poor.

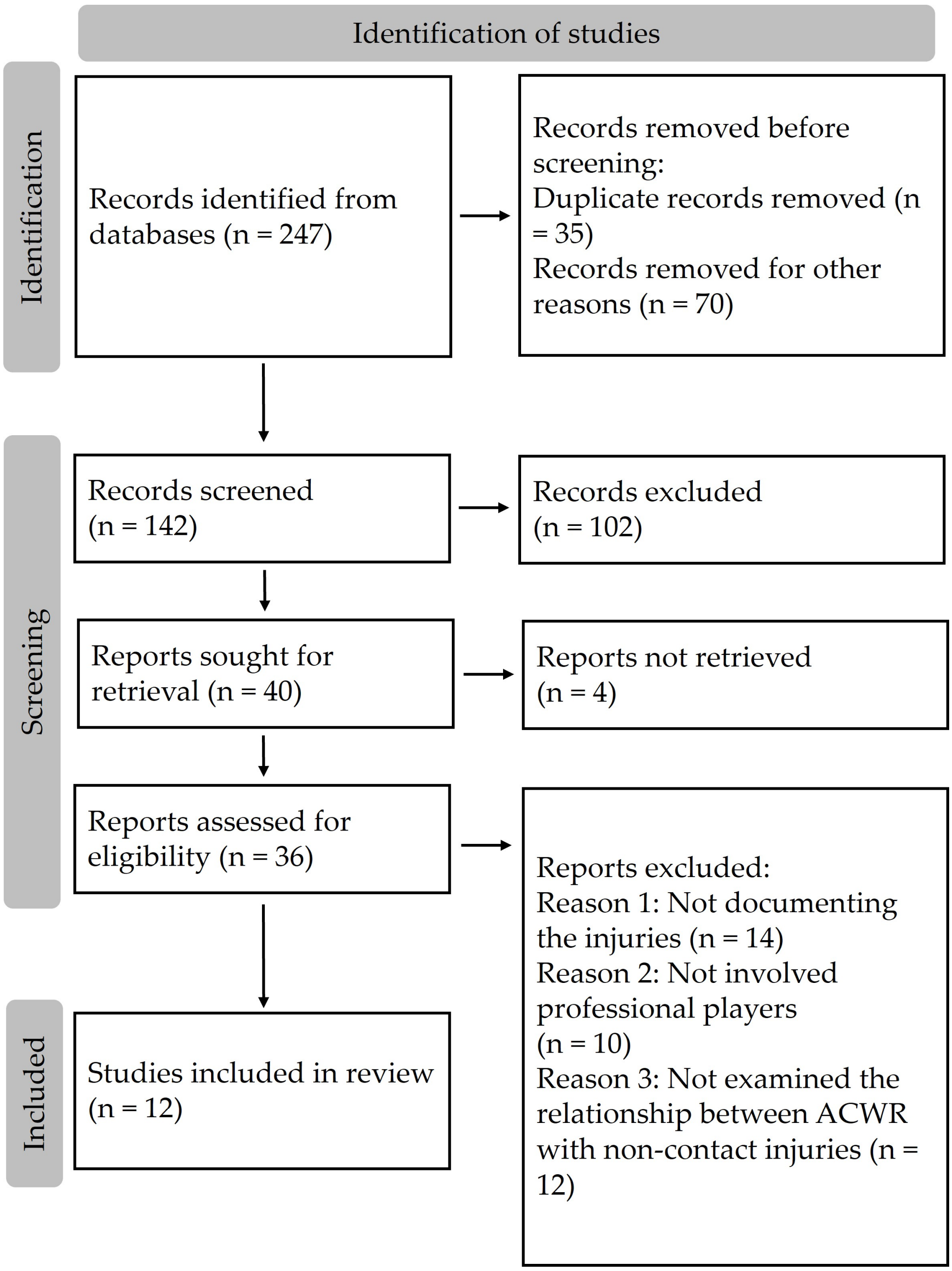

Figure 1. Flowchart of the search process and study selection.

3.3. Characteristics of the Studies

As previously mentioned, all studies included in the review are recent, and their participants are professional football players. Regarding the duration, five studies had a one-season duration [12,21,28,30,33], three studies had a two-season duration [19,29,31], two studies had a three-season duration [25,27], and only one study had a duration of 10 weeks [32]. In all studies, the ACWR was utilized in various forms.

Specifically, four studies exclusively used the coupled ACWR [19,25,28,29], and one used the uncoupled ACWR 1:4 [32]. Three studies investigated not only the ACWR of 1:4 but also other ratios, such as 1:2 and 1:3 [12,21,27]. One study explored the uncoupled ratio of 1:3 [31]. Additionally, two studies [26,30] investigated two new approaches to the ACWR, while in one study [33], the exponentially weighted moving averages (EWMA) ACWR was examined.

Regarding the workload variable to which the ACWR was applied, six studies [21,26–29,33] used only the rating of perceived exertion (RPE). Four studies used external workload indicators from GPS [12,25,31,32]. One study used a combined metabolic load indicator [30], while another study [17] employed internal (RPE) and external workload indicators (TD, HSR, ACC, and DEC). The characteristics of the studies are presented in Table 2.

Table 2. Characteristics of the studies and association of ACWR with injuries.

Study	Year	Sample Size	Duration	Variables	Number of Injuries	Kind of ACWR	Results/Conclusions
Bowen et al. [25]	2020	33	3 seasons	TD, LID, HSD, SD, ACC, DEC	91	Coupled 1:4	The highest risk of non-contact injuries occurred when there was a low chronic exposure to decelerations (<1731) and the ACWR exceeded 2.0. Similarly, the risk of non-contact injuries was 5–6 times greater for accelerations and low-intensity distance when chronic workloads were classified as low and when the ACWR surpassed 2.0, compared to instances where the ACWR was below this threshold. When considering all chronic workloads, an ACWR exceeding 2.0 was linked to a significant but comparatively lower injury risk for the same metrics, including total distance.
Carbone et al. [26]	2022	35	>6 months	RPE	30	Coupled 1:4 and ACWR randomly generated	The likelihood of experiencing an injury, whether conditioned by ACWR or a randomly generated ACWR, remained consistent across all estimated quantiles, and the distinctions between them lacked statistical significance. Conclusions drawn indicate that the ACWR ratio, when employing internal load monitoring, does not demonstrate superior predictive capabilities compared to a synthetic ACWR generated with a random denominator for assessing the probability of injury. It is advised not to rely solely on ACWR in isolation for analyzing the causal relationship between load and injury.
Delecroix et al. [21]	2018	130	1 season	RPE	237	Coupled 1:2, 1:3, 1:4	The occurrence of injuries was elevated when the A/C ratios for 4-week and 2-week periods were below 0.85. Similarly, increased injury incidence was observed when the 2-week A/C ratio deviated from the 0.85–1.25 range. Nevertheless, the presence of low sensitivity and/or specificity values, along with minimal changes in the probability of injury, suggested that workload, when considered in isolation, is not a reliable predictor of injuries. None of the A/C workload combinations proved suitable for accurately predicting injuries.
Fanchini et al. [27]	2018	34	3 seasons	RPE	90	Coupled 1:2, 1:3, 1:4	Considering these results, even when acute/chronic ratios are very high (based on the current sample), predicting injuries seems improbable. Although there was an association between acute/chronic markers, their predictive capability was limited.
Fousekis et al. [12]	2022	35	1 season	TD, HSD, SD, ACC, DEC	9	Coupled 1:2, 1:4	In this study, both models assessing ACWR4 and ACWR2 provide insights into the potential likelihood of non-contact injuries in professional soccer players. The ACWR2 model appears to be a more sensitive indicator, as the differences were more pronounced across a greater number of examined variables. The findings suggest that ACWR is associated with the subsequent occurrence of injuries, but the threshold for ACWR can vary. This variability is primarily influenced by evaluating the load of the last two weeks in comparison to the load of the four weeks preceding the injury.
Jaspers et al. [19]	2018	35	2 seasons	TD, HSD, ACC, DEC, RPE	64	Coupled 1:4	An elevated ratio for HSD (>1.18) led to an increased risk of injury, while lower injury risks were observed when comparing moderate ratios for ACC (0.87–1.12), DEC (0.86–1.12), and RPE x duration (0.85–1.12) to low ratios.
Malone et al. [28]	2017	48	1 season	RPE	75	Coupled 1:4	Nevertheless, players who maintained comparable in-season acute/chronic workload ratios ranging from >1.00 to <1.25 exhibited a further diminished risk of injury.
Mohr et al. [29]	2023	32	2 seasons	RPE	33	Coupled 1:4	There was no association between ACWR and injury occurrence.

Table 2. *Cont.*

Study	Year	Sample Size	Duration	Variables	Number of Injuries	Kind of ACWR	Results/Conclusions
Nobari et al. [30]	2022	21	1 season	Training load marker (BL) from GPS and accelerometer	21	ACWR = Awn/(Awn − 1 + Awn − 2 + Awn − 3) × 0.333	ACWR appears to be a good indicator for estimating the injury risk.
Ribeiro-Alvares et al. [31]	2023	48	2 seasons	TD, HSD, SD	20	Uncoupled 1:3	Considering that three-quarters of hamstring injuries in professional soccer players were preceded by ACWR values below 1.5 across all GPS metrics, it is advisable for medical and coaching staff to exercise caution when relying solely on the ACWR 'danger zone' as the primary metric to assess player availability for training or matches.
Suarez-Arrones et al. [32]	2020	15	10 weeks	TD, HSD, SD	1	Uncoupled 1:4	The current study indicated that spikes in the ACWR did not correlate with subsequent injury incidents among professional soccer players.
Tiernan et al. [33]	2022	15	1 season	RPE	21	Uncoupled 1:4 and exponentially weighted moving averages (EWMA) ACWR	A rise in ACWR by 0.1, surpassing 1.0, elevated the likelihood of a non-contact injury occurring five days later, with 62% of injuries taking place if ACWR was above 1.20. Moreover, this study revealed that five days preceding an injury (contact or non-contact), a player faced a 30% heightened risk of a non-contact injury and a 26% increased risk of a contact injury if the EWMA ACWR increased by 0.1, surpassing 0.97. The findings suggest that EWMA ACWR might be a more sensitive measure for identifying players at a higher risk of injury compared to ACWR.

4. Discussion

The ACWR was introduced in the previous decade with the aim of monitoring training loads to prevent non-contact injuries. This ratio is formed with the acute load in the numerator, representing the player's workload in the last week, and the chronic load in the denominator, representing the workload over the last 2, 3, or 4 weeks. Researchers attempted to provide specific thresholds for the ACWR to limit the likelihood of non-contact injuries. The proposed ideal range for the ratio was between 0.8 and 1.3, with an increased injury probability when the ratio exceeded 1.5 or was below 0.8, forming a U-shaped relationship [11].

In a previous study, it was noted that different sports may have different thresholds in the relationship between training load and injury [10]. This variability was one of the reasons for focusing on adult professional football players in the current review.

4.1. ACWR in Relation to RPE or External Variables

Among the six studies using the RPE for the ACWR, four [21,26,27,29] did not observe a relationship between the ratio and injuries, in contrast to the other two [28,33]. Delecroix et al. (2018) [21] found an increased injury frequency when the ratio deviated from the range of 0.85 to 1.25. However, they stated that no combination of ratios (1:2, 1:3, and 1:4) was suitable for injury prediction. In the same year, another study [27] reported a relationship between the ACWR and injury occurrence, but without the ability to predict injuries. In two more recent studies [26,29], no relationship was observed between the ratio and injury occurrence.

Of the six studies using GPS indicators (TD, HSD, SD), two [31,32] found no relationship between the ACWR value and injury occurrence. In contrast, four studies [12,19,25,30] observed a relationship between the ratio value and the probability of injury. Specifically, Ribeiro–Alvares (2023) [31] used the uncoupled ACWR 1:3 and noted that three-quarters (3/4) of hamstring injuries occurred after loads with a ratio value less than 1.5. The researchers concluded that the ratio cannot be the primary indicator for assessing the availability of professional football players for training or matches. In a previous study [32], the uncoupled 1:4 ACWR was applied, and no spikes in the ACWR were related to subsequent injuries in professional soccer players. In contrast, Jaspers et al. (2018) [19] applied the coupled 1:4 ACWR and found an increased injury risk when the ratio in the HSD was >1.18 and a lower risk for medium ratios compared to low ratios for factors like ACC (0.87–1.12), DEC (0.86–1.12), and RPE x duration (0.85–1.12). In a subsequent study [25], when the ratio value exceeded two, the risk of injury increased. Nobari et al. (2022) [30] created an alternative form of ACWR (see Table 2) and observed that this ratio is a good indicator for assessing the risk of injury. Additionally, Fousekis et al. (2022) [12] observed that ratios of 1:2 and 1:4 were related to injury occurrence, with the 1:2 ratio appearing to be a more sensitive indicator.

An observation regarding the type of variables used for the ACWR and the findings is that the majority of studies using the RPE indicator (4 out of 6) did not observe a relationship between the ratio value and the likelihood of injury. The RPE indicator reflects the internal workload and has been suggested to mirror the external load on the player [34]. However, it is not a direct measurement indicator, and this detail may affect the outcome of the ratio. This ratio flips in studies using external workload indicators from GPS devices (four studies found a relationship, and two did not). Moreover, one of the two studies that did not find a relationship had a duration of only 10 weeks, a time frame that may not be sufficient for injury occurrence and ratio assessment. Finally, these two studies applied the uncoupled ACWR, in contrast to the other four studies that applied the coupled ACWR.

4.2. Most Important Variables for ACWR

From the 12 studies mentioned, six utilized the rating of perceived exertion (RPE) to calculate the acute-to-chronic workload ratio (ACWR). It is known that this index provides a safe representation of the internal load in trained athletes [34]. The RPE is easy to use and requires minimal equipment, making it one of the most commonly used indices for monitoring workload by coaching staff. In this review, four out of six studies exclusively using this index did not find a significant relationship with the likelihood of injury. However, considering the positive aspects mentioned earlier, we believe that this index can be monitored in conjunction with other variables.

The most common global positioning system (GPS) variables used in three studies were total distance (TD), low-speed distance (LSD), high-speed distance (HSD), sprint distance (SD), accelerations (ACC), and decelerations (DEC). Jaspers et al. (2018) [19] observed that when the ACWR for total distance was <0.88 or >1.11, there was an increased likelihood of injuries. Fousekis et al. (2022) [12] reported a significant difference in the ACWR 1:2 ratio for total distance between injured and non-injured players. Bowen et al. (2020) [25] found an increased risk of injuries when the ACWR was >2.14 for TD. Additionally, this study was the only one reporting a relationship between LSD and injury probability (5–6 times higher) when the chronic load was low, and the ACWR was >2.

Regarding high-speed distance (HSD), Jaspers et al. (2018) [19] reported an increased risk of injury when the ratio was >1.18. Fousekis et al. (2022) [12] observed differences in the 1:2 and 1:4 ratios for distances at speeds of 15–20 km/h and 20–25 km/h, indicating that thresholds may need differentiation. In the 1:2 ratio, values were >1, while in the 1:4 ratio, values were >1.07.

A crucial factor in soccer is sprint distance (SD). Among the three studies, only Fousekis et al. (2022) [12] investigated the relationship between the ACWR and sprint distance. Specifically, the researchers found that for the 1:4 ratio, a value greater than 1.58 and for the 1:2 ratio, a value greater than 1.47 increased the risk of non-contact injuries.

The variables included in all three studies were accelerations (ACC) and decelerations (DEC). Jaspers et al. (2018) [19] observed that medium ratios of ACC (0.87–1.12) and DEC (0.86–1.12) showed a lower risk of injuries compared to lower ratio values. Bowen et al. (2020) [25] reported an increased likelihood of injuries (5–7 times) when the ratios for ACC were >2.3 and DEC were >2.32. Fousekis et al. (2022) [12] noted an increased injury probability when the 1:4 ratio was >1.32 and the 1:2 ratio was >1.16.

Nobari et al. (2022) [30] modified the ACWR and used a workload index from GPS and accelerometers. Their study results indicated that a higher ACWR was associated with more injuries.

From the above, it is evident that studies applying the ACWR to professional soccer players using GPS variables are limited. No secure conclusions can be drawn regarding which variables can be used by sports scientists to predict injuries. The review revealed studies supporting the relationship between the ACWR and injury probability for all explored factors, as well as studies denying the existence of such a relationship.

4.3. Couple or Uncoupled ACWR

Another parameter is whether a coupled or uncoupled ACWR was used. The coupled ACWR includes the acute load within the chronic load, while the uncoupled ACWR does not include the acute load in the chronic load. Among the studies in this review, eight studies [12,19,21,25–29] used the coupled ACWR, and three studies [31–33] used the uncoupled ACWR. In half of the studies using the coupled ACWR, a relationship between the ratio and the likelihood of injury was observed [12,19,25,28]. In studies with the uncoupled ACWR, only one study [33] observed a relationship, reporting that an increase in the ratio by 0.1 raises the probability of non-contact injury five days later, with 62% of injuries occurring when the ratio was at 1.2.

In the same study, another form of the ratio was investigated, the exponentially weighted moving averages (EWMA) ACWR. According to this, more emphasis is given to the recent training load compared to the older load [22]. Researchers observed that an increase of 0.1 above the value of 0.97 leads to a 30% increase in the probability of non-contact injuries.

4.4. Duration of ACWR

Out of the twelve studies, only three utilized different durations for the ACWR [12,21,27]. In the first of these studies [21], the researchers observed that the injury probability was lower when the 1:4 ratio was <0.85. Additionally, for the 1:2 ratio, they reported an increased injury probability when the value was outside the range of 0.85–1.25. However, they noted that low sensitivity/specificity does not advocate for the use of the ratio in injury prediction. In another study in the same year [27], the researchers investigated the ratios 1:2, 1:3, and 1:4, observing a relationship between all ratios and the probability of injuries, albeit with poor prediction ability. Finally, Fousekis et al. (2022) [12] studied the 1:2 and 1:4 ratios, reporting relationships for both ratios with the probability of injuries, with the 1:2 model appearing to be more sensitive.

4.5. Practical Applications

Sports scientists can use the ACWR in conjunction with other tools to predict the likelihood of non-contact injuries. Regarding the parameters that can be applied, these include TD, HSD, ACC, and DEC. Also, the duration of the ratio seemed not to affect the outcome, so sports scientists can use any duration of the ratio (1:2, 1:3, 1:4) that serves the team's periodization.

4.6. Study Limitations

The study has certain limitations. Initially, only research in the English language was used. Additionally, only studies related to professional male soccer were included, excluding research conducted on females. Furthermore, the ACWR was evaluated exclusively, without considering any other tool that could potentially present different results when used in combination. More specifically, the studies could mention all the methods and prevention programs they possibly implement and evaluate this very important factor as well. The review was not registered, and a protocol was not prepared.

5. Conclusions

From this review, it appears that studies regarding the utility of the ACWR in predicting injuries in professional football are limited. The majority of research confirming the relationship between the ACWR and the probability of injuries used GPS indices (TD, HSD, ACC, DEC). Different values for the ACWR were reported in these studies for the various indices used, indicating the difficulty in establishing thresholds indicating lower injury risks. The RPE index is particularly user-friendly, and it is advisable to use it in combination with other indices, as only two out of six studies confirmed its utility for this purpose. Regarding the use of a coupled or uncoupled ACWR, no safe conclusions can be drawn from the results of this review. Also, concerning the duration of the ratio (1:2, 1:3, or 1:4), it seems not to influence the correlation between the ratio and the probability of injuries.

However, it should be noted that applying the ACWR in professional football is challenging due to the lack of stable periodization in matches. Specifically, the microcycle of professional football can vary depending on the team's matches. Players participate in matches with their team related to the league, cup, and European cups, as well as matches with national teams. Therefore, extra matches or the absence of competitive obligations in the microcycle can significantly alter the ACWR and complicate the monitoring of the load.

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